Solar Power - for Sustainable Energy
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External Cost of Solar Electricity
- and the context

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Presentation Outline

- Aims and principles of Impact Pathway Approach (IPA)
- Important pollutants and impacts considered
- Example for impact assessment – “from emission to external costs”
- Specification of Solar Electricity Technologies
- LCI data and corresponding external costs analysis
- Context – Comparison with external and internal, i.e. social costs of other new technologies – state of the art 2010
- Social costs solar electricity - state of the art 2030
- Summary

Aim of the External Costs - Methodology: ➔ helps to take into account all externalities in a consistent way when making decisions:

- ✓ ***Investment decisions***
- ✓ ***Technology Assessment (subsidies, research support)***
- ✓ ***Consumer decisions (e.g. by adjusting prices, by internalisation of external costs)***
- ✓ ***Cost-benefit analyses, esp. for environmental and health regulation***
- ✓ ***Green accounting***

Basic principles

1) *Pressures, e.g. emissions of substances to environmental media have to be estimated (LCI)*

2) *Assessment of effects/impacts (e.g. health risk) caused be the pressures*

→ **relation between pressure and impact is in general not linear and**

→ **impacts depend on time and location of pressure**

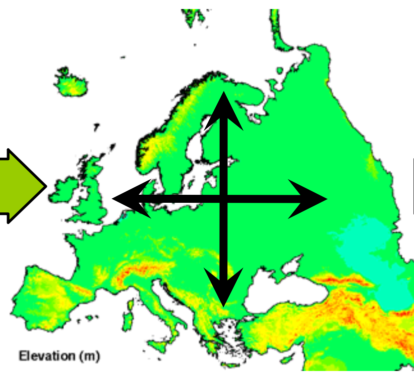
➔ ***"Bottom-up approach" needed to account for the complex pathways:***

***the 'Impact Pathway Approach'* (IPA)**

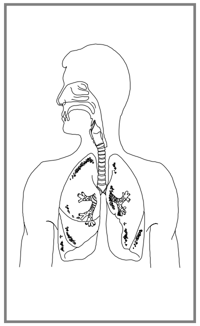
Impact Pathway Approach (IPA) – first part

Emission = LCI data

Transport and Chemical Transformation



Damage



Pressures included:

- ***Classical air pollutants (NH_3, NMVOC, NO_X, PPMco, PPM2.5, SO_2)***
- ***Greenhouse gases***
- ***Heavy metals & radio nuclides***
- ***POPs & Dioxins***
- ***Noise and Landuse change***

Impacts included:

- ***Human Health***
- ***Crops and building materials***
- ***Biodiversity***
- ***Climate Change….***

→ Example: Classical air pollutants

<u>From</u> dust, SO_2, NH_3, NO_x & NMVOC emission to air

<u>via</u> dispersion and chemical transformation

<u>to</u> concentrations and depositions of:

- ✓Fine primary particles with diameter below 2.5 µm (PPM2.5)
- ✓Coarse primary particles with diameter between 2.5 and 10 µm (PPMco)
- ✓**S**econdary **I**norganic **A**erosols (SIA): ammonium nitrate and sulphate particles
- ✓Dry and wet deposition of oxidized and reduced nitrogen
- ✓Dry and wet deposition of sulphur
- ✓Ozone (SOMO35: sum over means of 35 ppb)

Quantification of Impacts and Costs

Relation between pressure and impact

Concentration Response Function (CRF):

Example: Additional **Y**ears **o**f **L**ife **L**ost

$= \Sigma\ \Delta \text{conc. PPM2.5} * \textit{Population} * 6.5 \cdot 10^{-5}$

Number of Years of Life Lost [YOLL] due to 1 tonne of fine dust PPM2.5 emitted at a location in Europe leads to a range of ca.

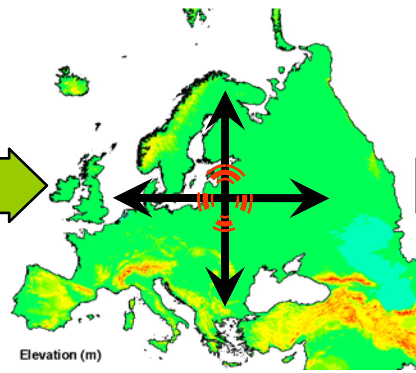
0.01 to up to 15 life years lost

– depending on location and height of release.

Impact Pathway Approach → **Weighting and Aggregation**

Emission

Transport and Chemical Transformation



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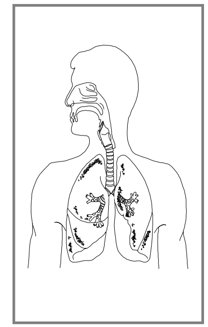


Monetary Evaluation

Basic principles -
Part 2: Quantification of Costs

Preferences of society are expressed, and

effects are transformed into monetary units:

- ✓ ***allows transfer of values***
- ✓ ***units are conceivable***
- ✓ ***direct use of results in CBA and for internalising via taxes possible.***

(…however, e.g. 'utility points' would give the same ranking).

Monetary Valuation

Health end-points	Euro per case / per YOLL
Increased mortality risk (infants)	3,000,000
New cases of chronic bronchitis	200,000
Increased mortality risk - YOLLacute	60,000
Life expectancy reduction - YOLLchronic	40,000
Respiratory hospital admissions	2,000
Cardiac hospital admissions	2,000
Work loss days (WLD)	295
netto Restricted activity days (netRADs)	130
Minor restricted activity days (MRAD)	38
Lower respiratory symptoms	38
LRS excluding cough	38
Cough days	38
Medication use / bronchodilator use	1

Quantification of Costs

Monetary value: 40,000 Euro per Year of Life Lost

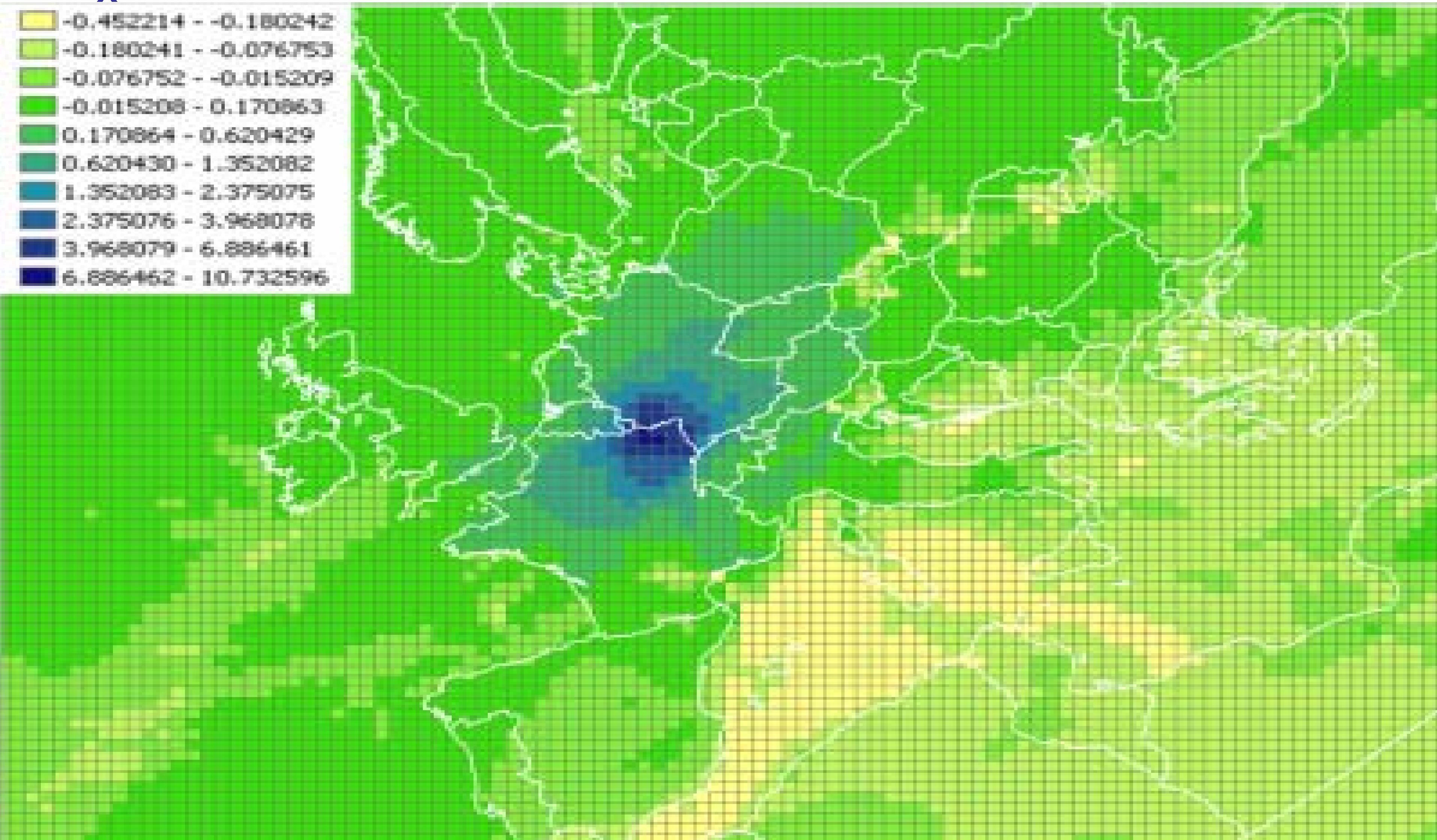
Damage costs Example:

0.5 YOLL per tonne PPM2.5 * 40,000 Euro per YOLL

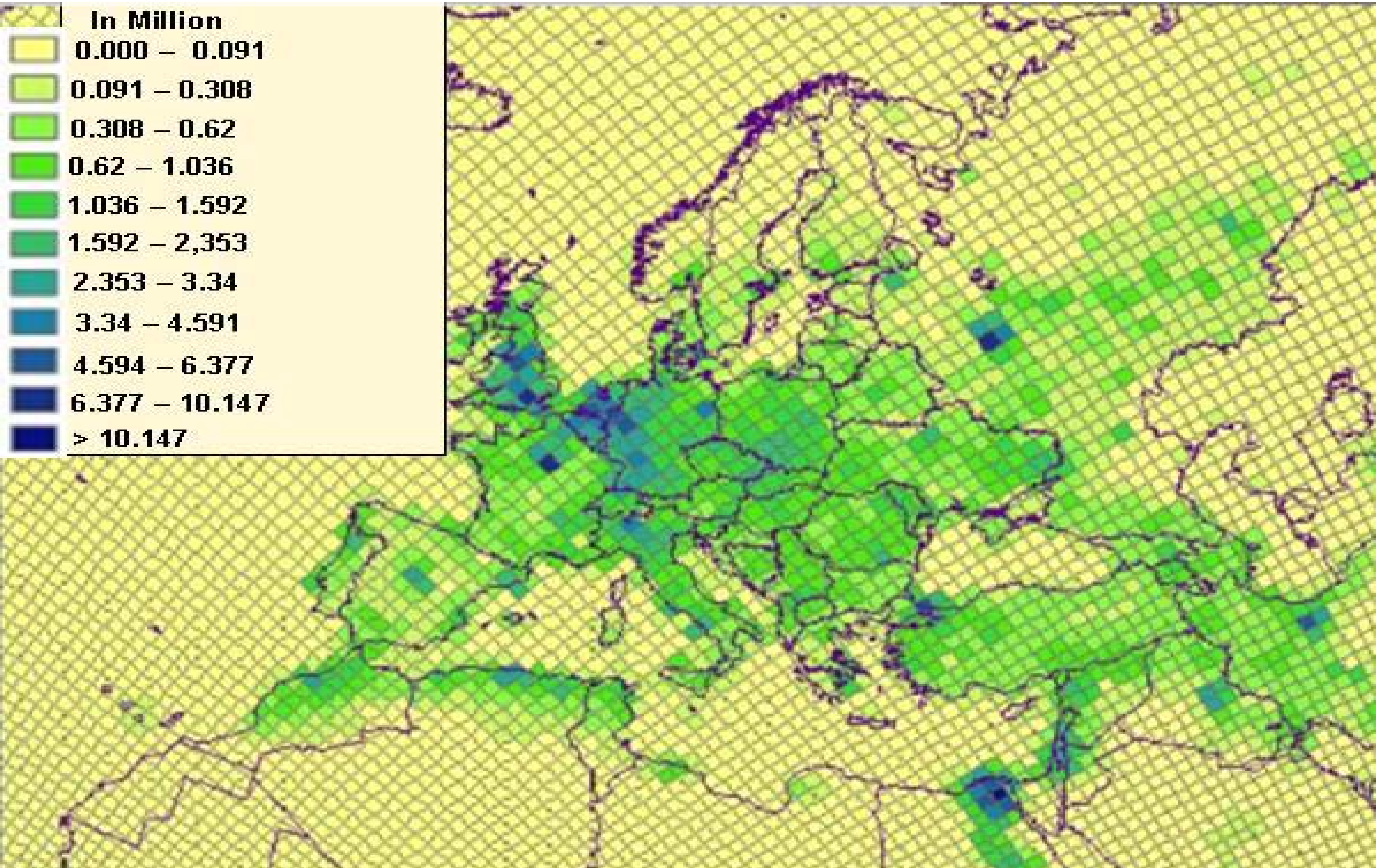
= 20,000 Euro per tonne PPM2.5

… and other air pollutants?

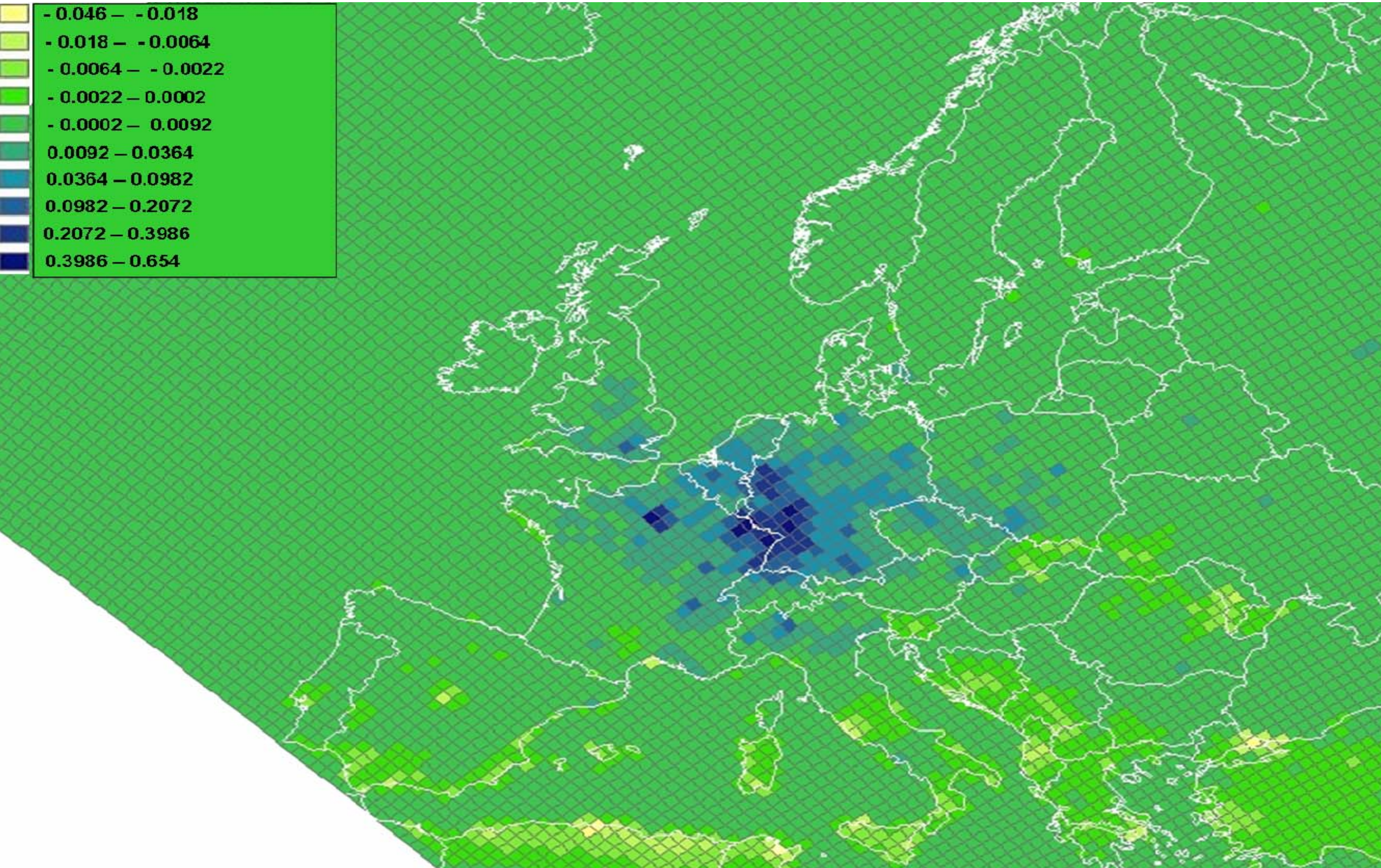
Concentration change of ozone [µg*day/m³] due to NO_x emission of a power plant close to Luxemburg



Population Distribution



Population * Delta Conc.* CRF → numb. of life years lost

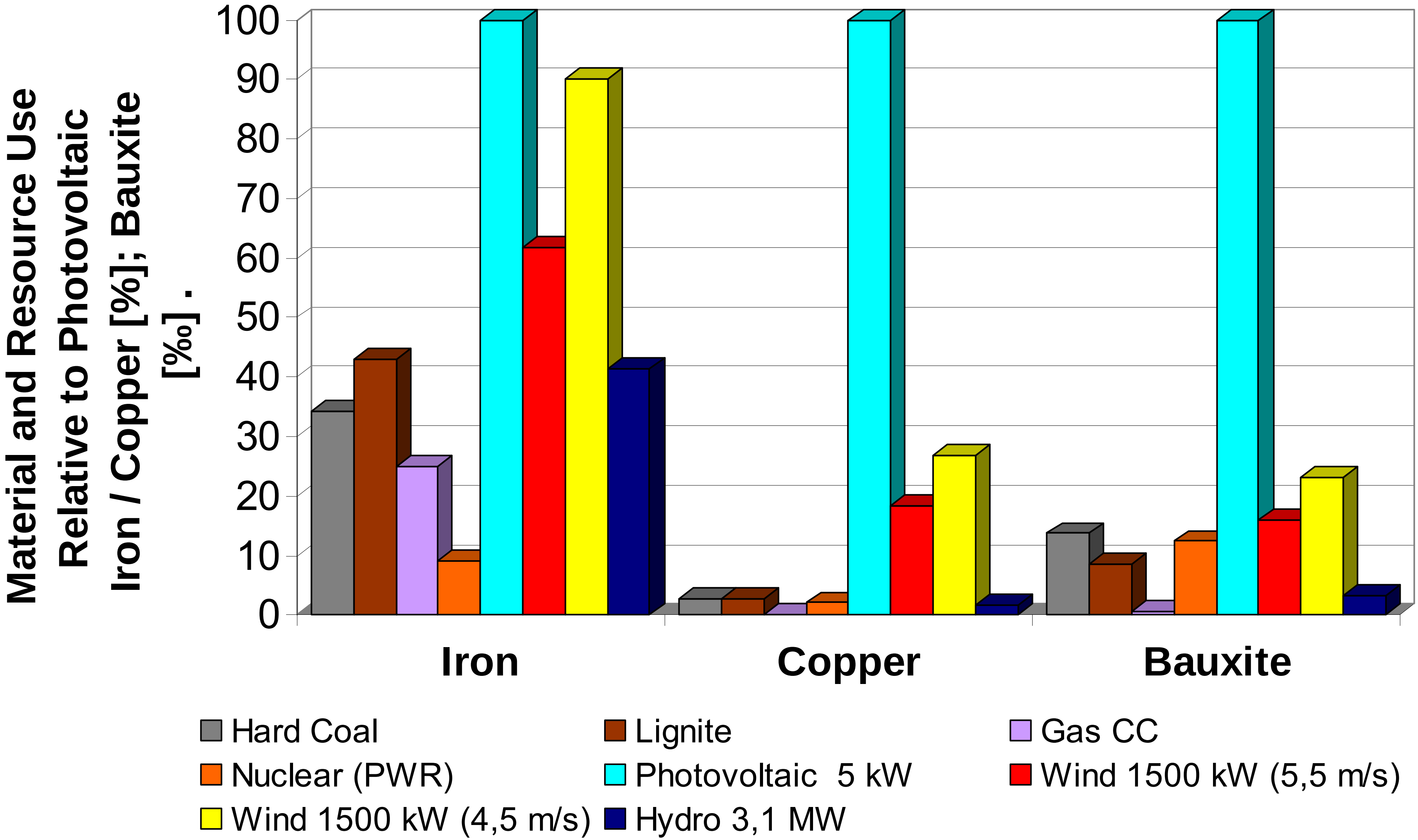


Specification of Solar Electricity Technologies at present

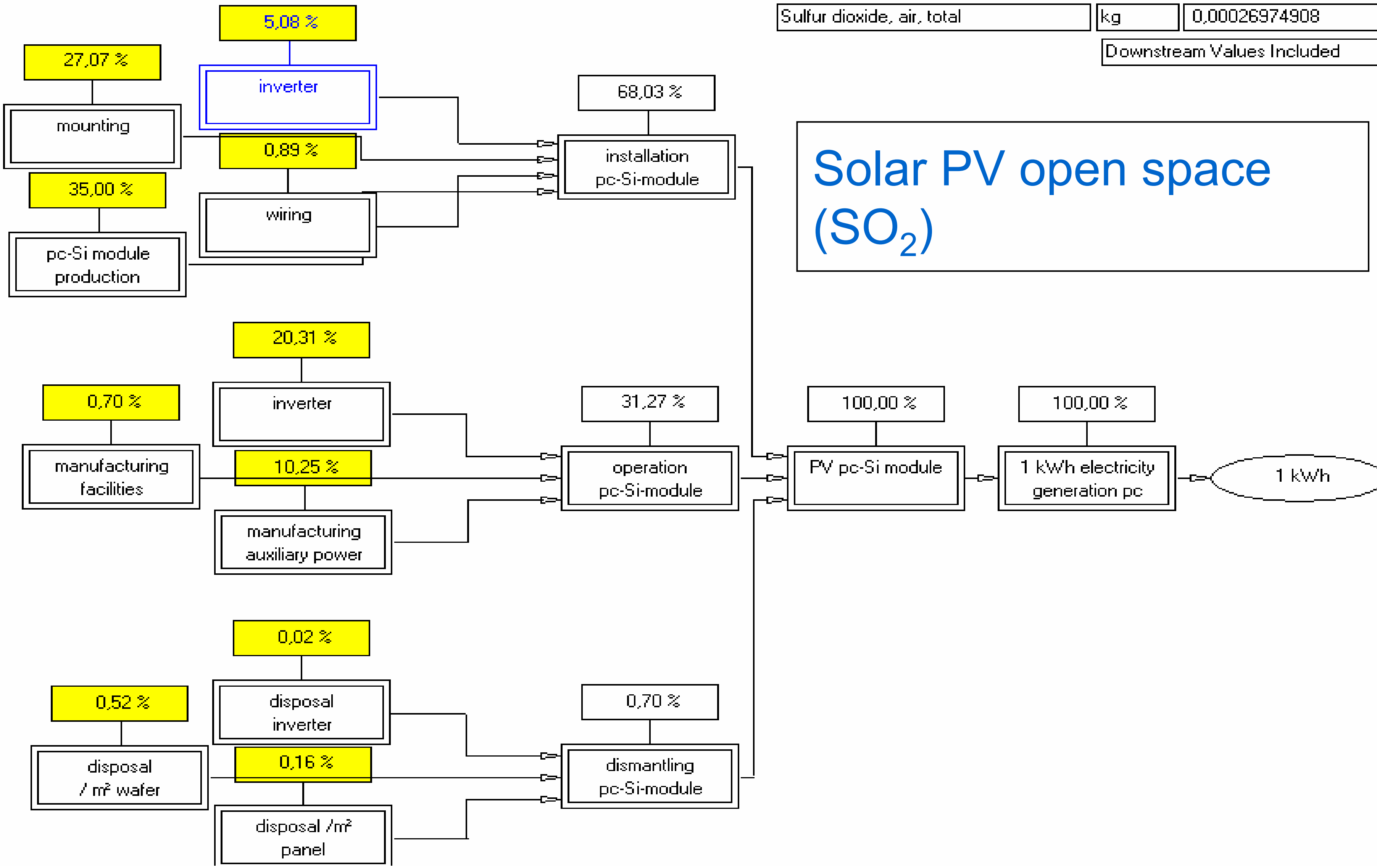
- ✓ **solar PV, roof (900 kWh/m²a)**
- ✓ **solar PV, open space (900 kWh/m²a)**
- ✓ **solar thermal, parabolic trough (1900 full load hours, > 2000 kWh/m²a)**

energy carrier	Technology	net el. power at el. peak load	el. efficiency at el. peak load	availability factor (full load hours)	tech. life time	spec. Investment costs (overnight capital costs)	spec. demolition costs (greenfield)	fixed costs of operation
		[MW]	[%]	[h/a]	[a]	[€/kW$_{el}$]	[€/kW$_{el}$]	[€/kW$_{el}$/yr]
PV	poly cristalline, roof	0.00312	15	1071	25	9400	0	94
	poly cristalline, open space	0.00312	15	1071	25	6500	0	65
solar thermal	solar trough	80	13.2	1900	30	3360	3	50.4

Material and Resource Use Relative to Photovoltaic (IER 2005)



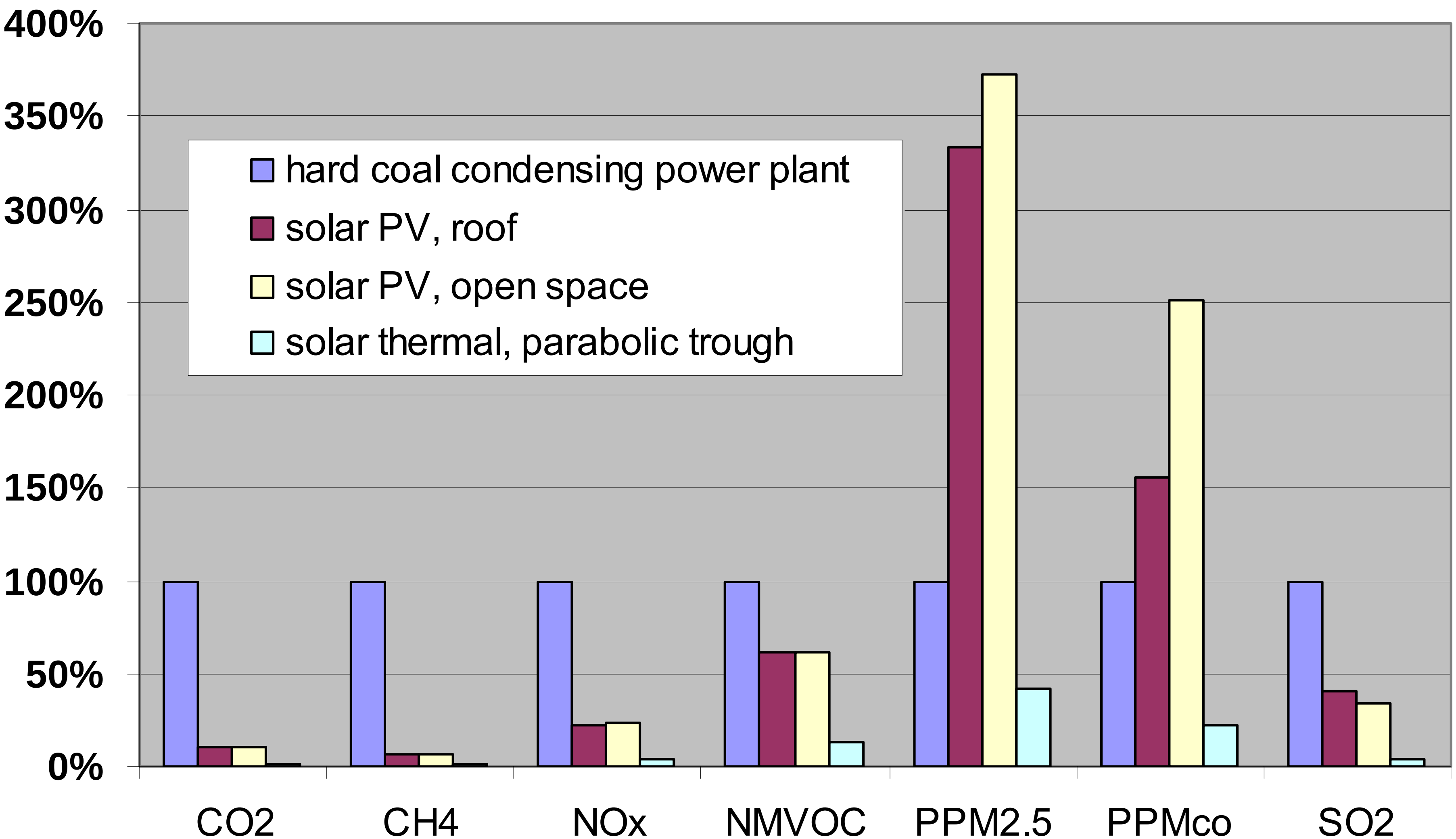
Life Cycle Analysis – LCI data derived with tool: Balance



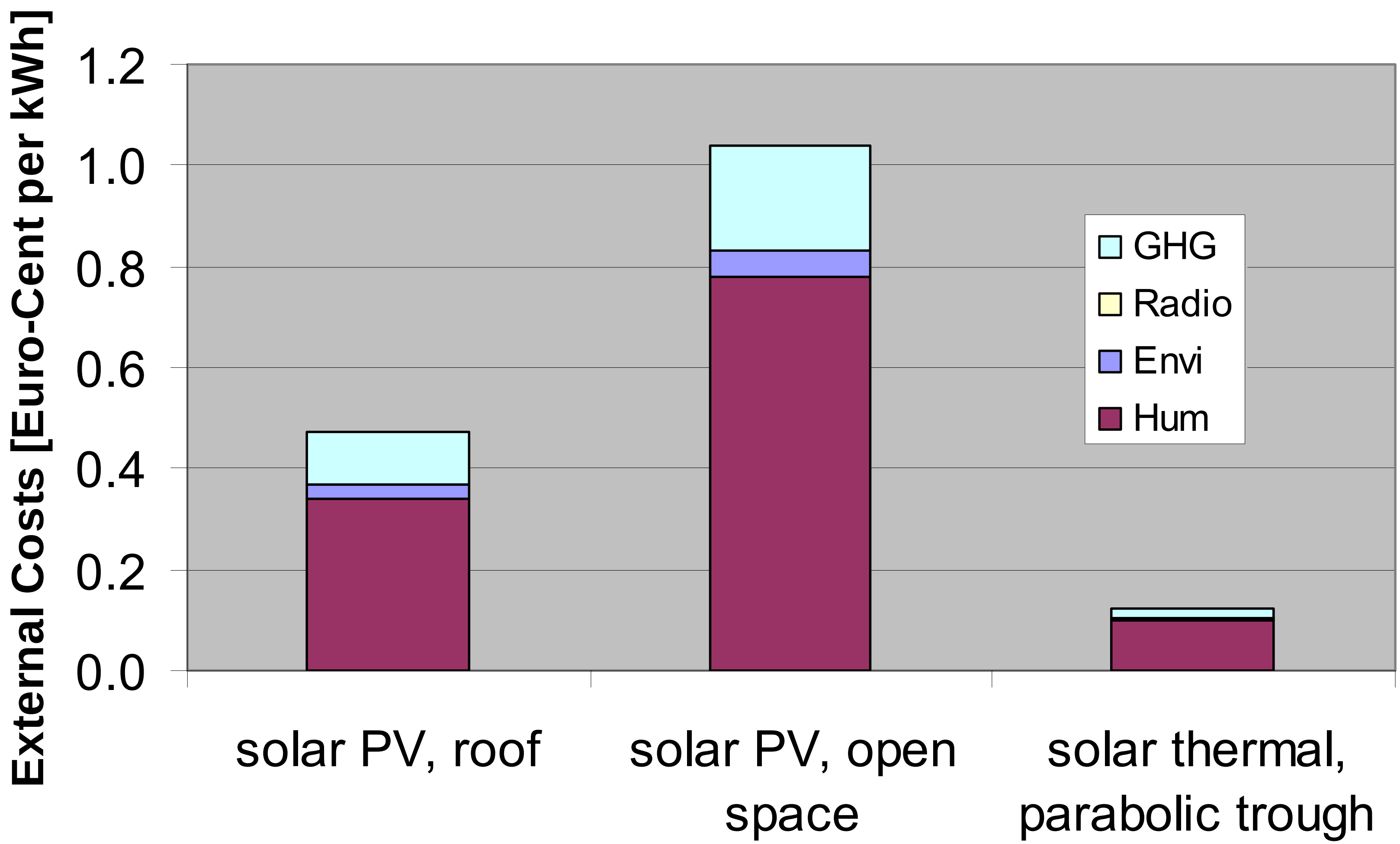
Solar PV open space (SO_2)

Emissions Relative to a Fossil Fueled Power Plant (present),

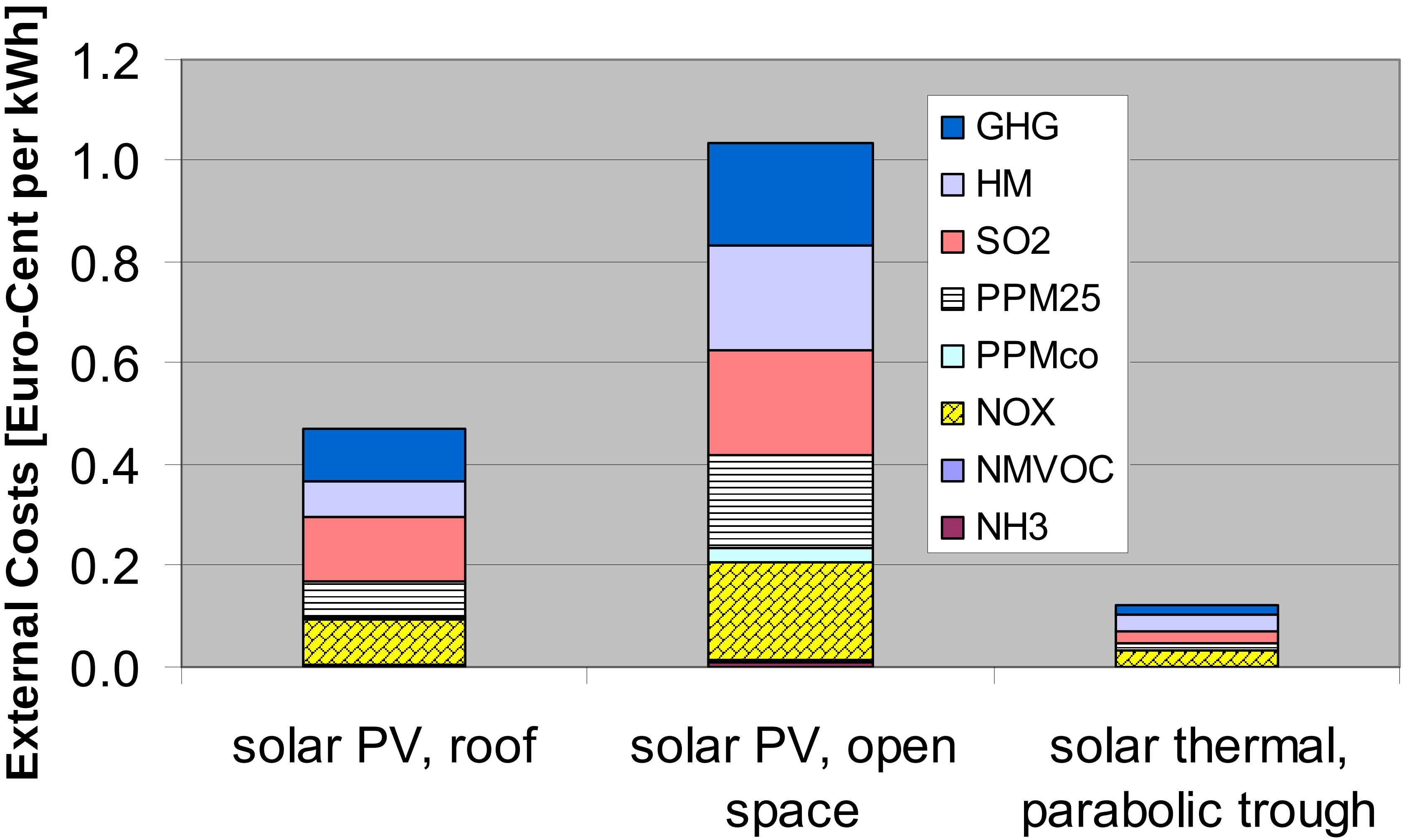
source (CASES 2008)



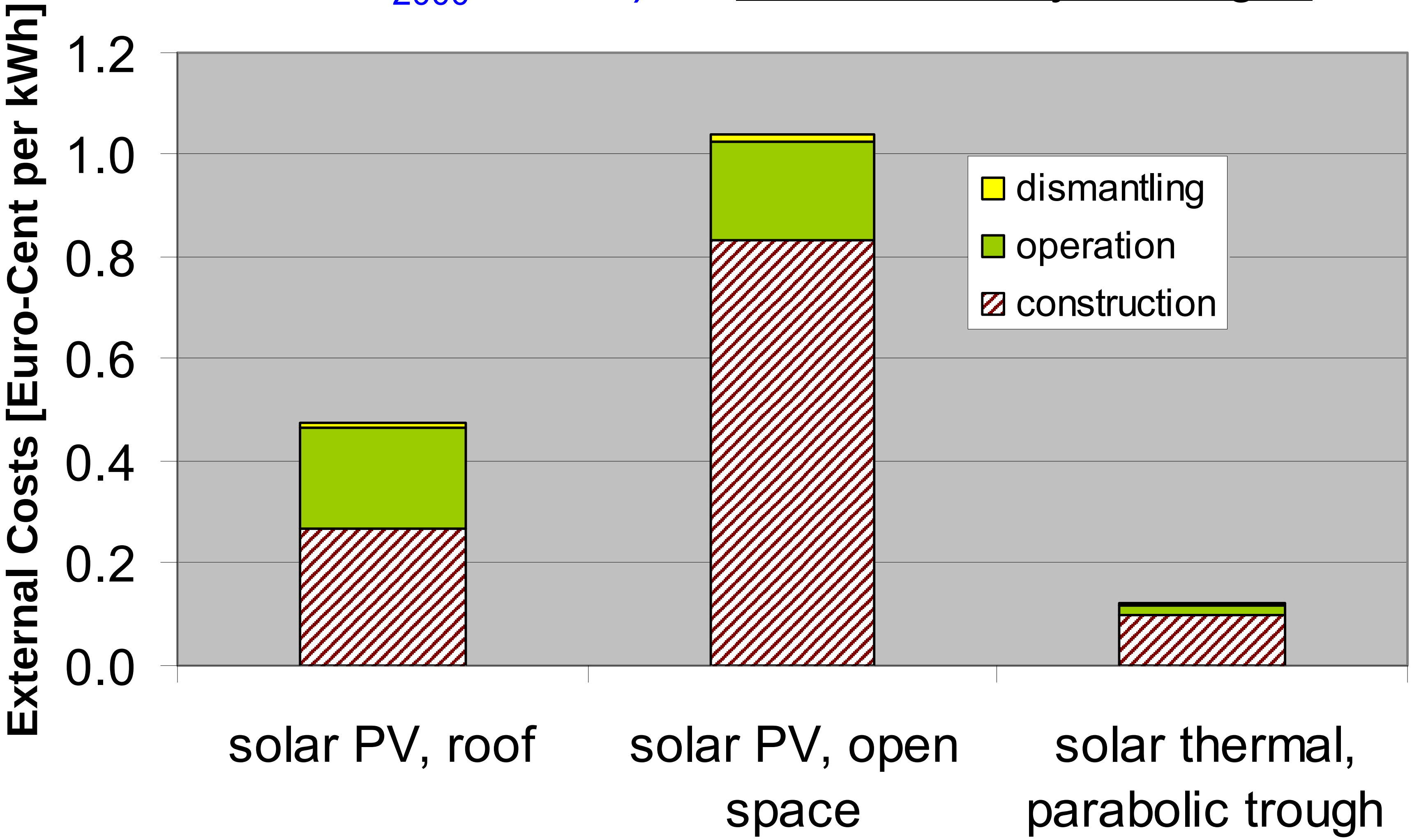
External costs of Solar Electricity Technologies (2010 in Euro-Cent$_{2000}$, EU27) different impact categories



External costs of Solar Electricity Technologies (2010 in Euro-Cent$_{2000}$, EU27) different pollutants

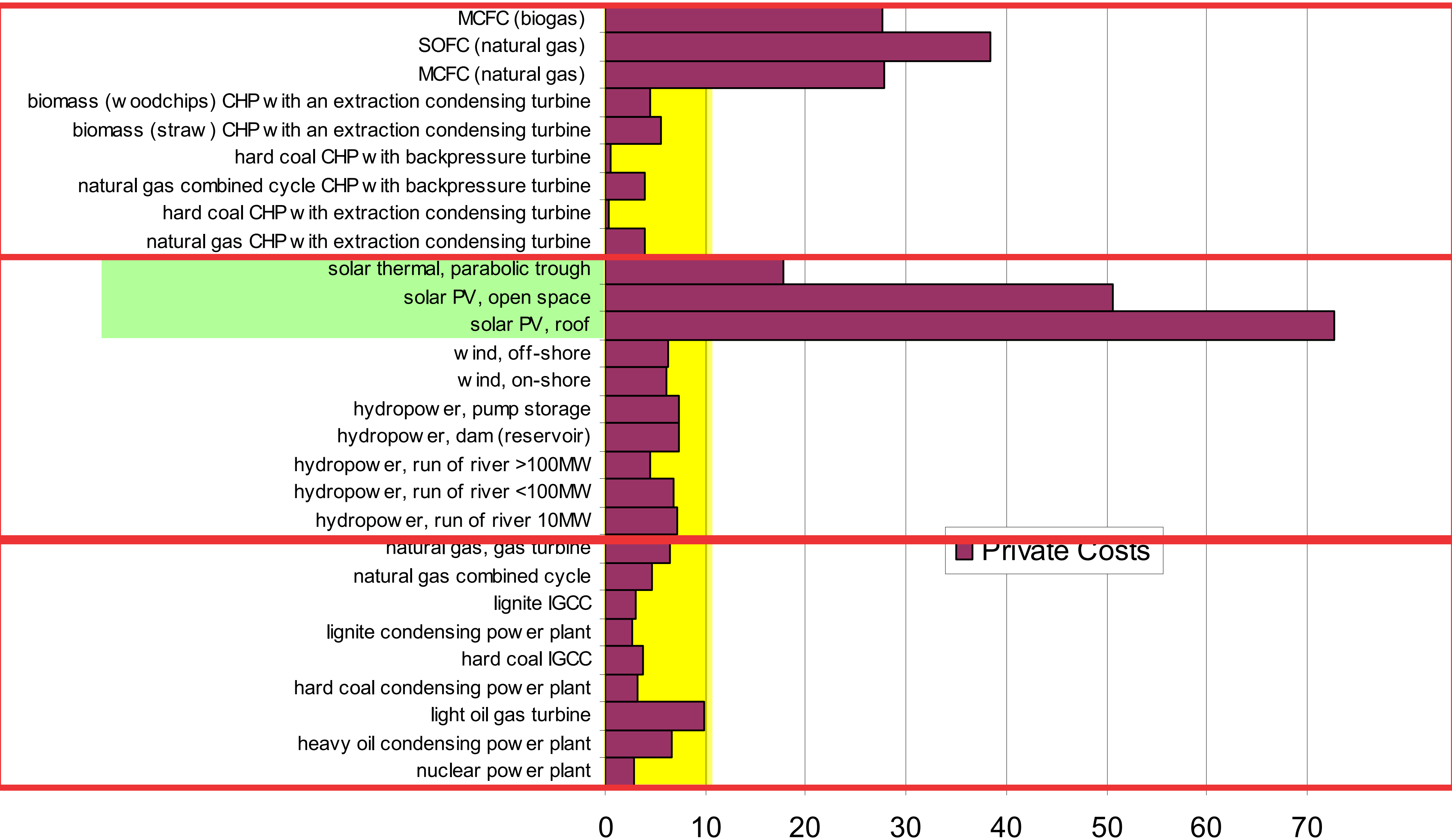


External costs of Solar Electricity Technologies (2010 in Euro-Cent$_{2000}$, EU27) different life cycle stages



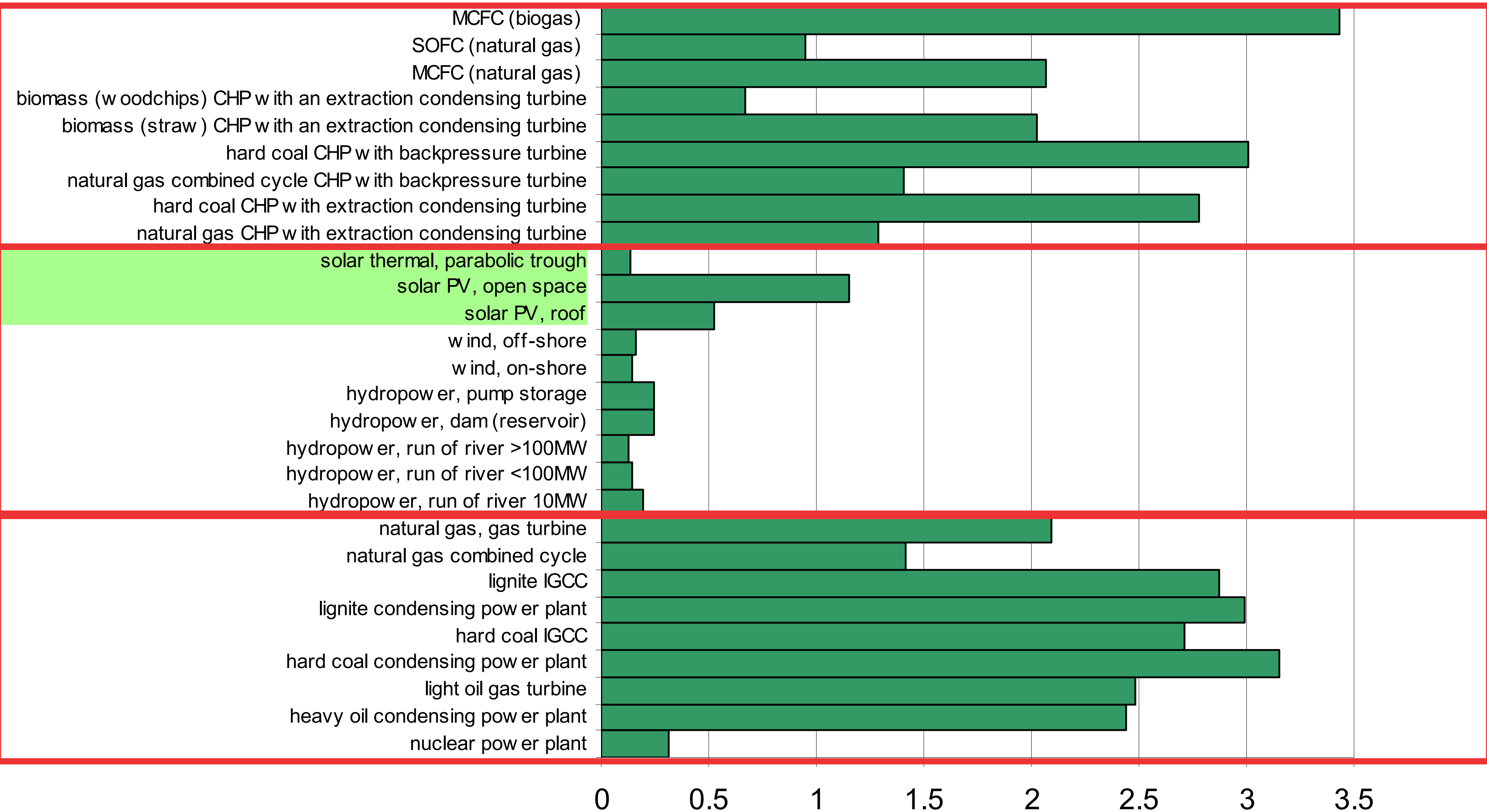
Context! Total Private Costs [Euro-Cent$_{2005}$ per kWh] in 2010

(CHP by „Exergy“& solar PV EU_mid, at present - New Technologies!)

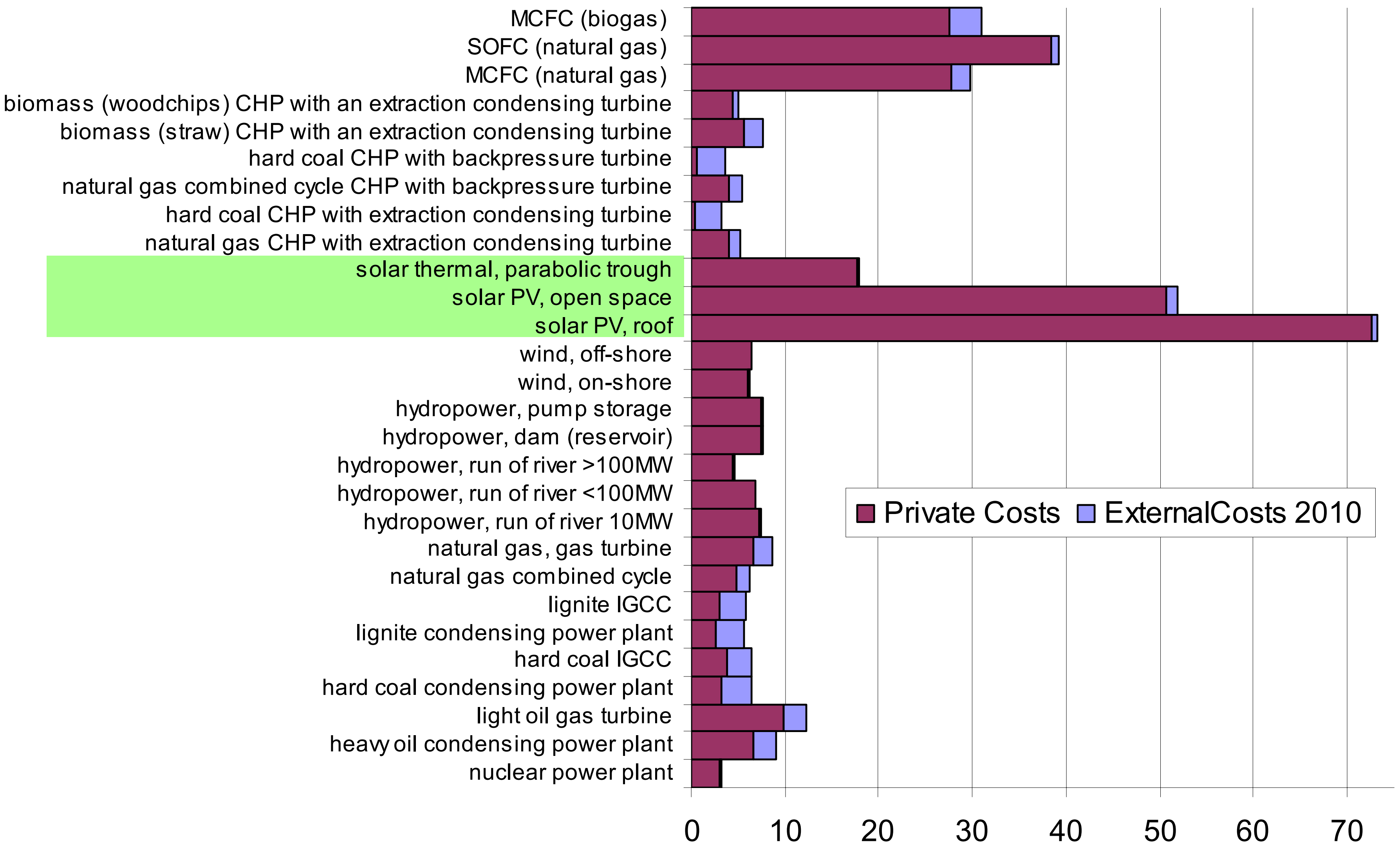


Context! Total External Costs [Euro-Cent$_{2005}$ per kWh] in 2010

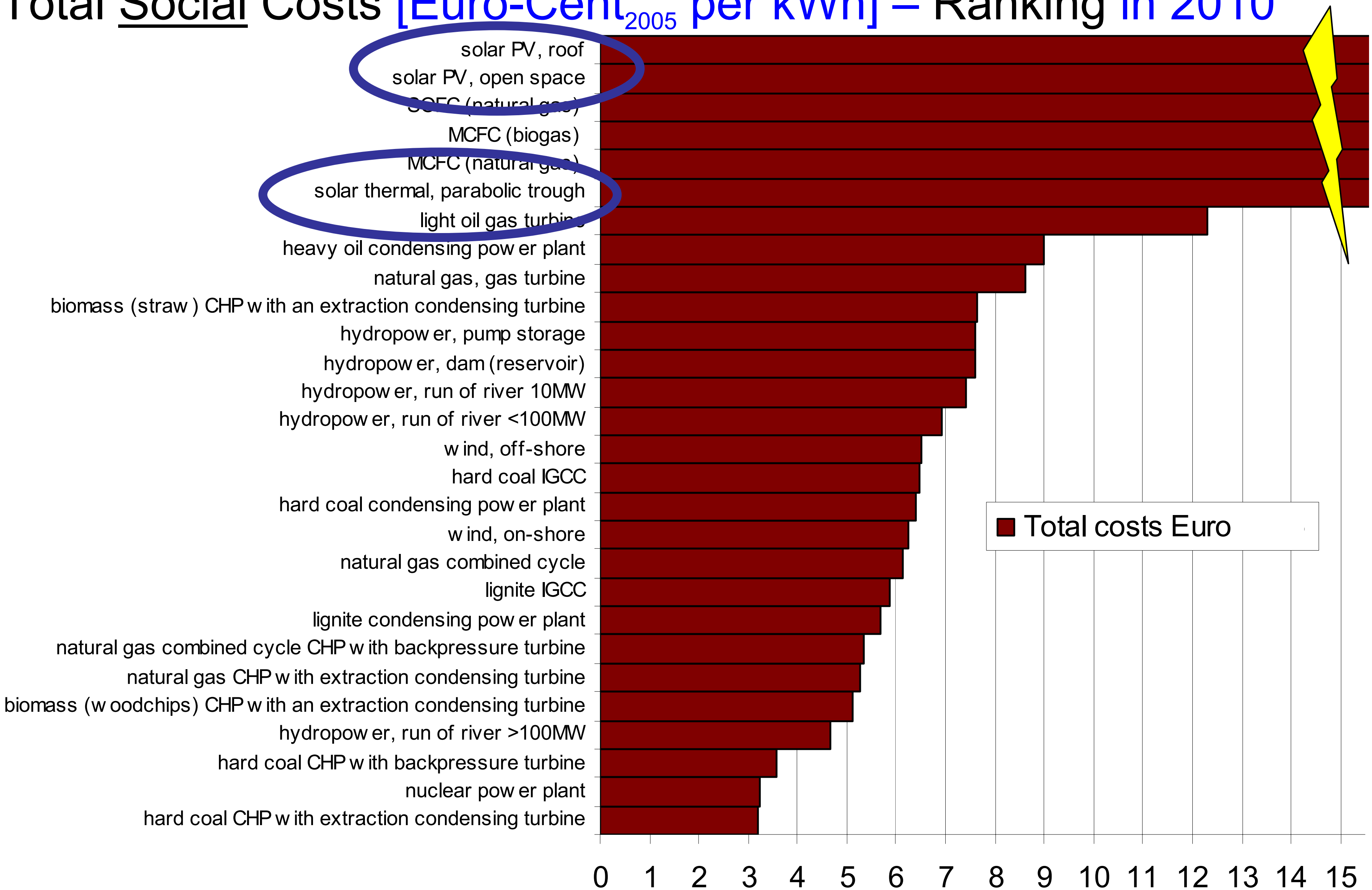
with GHG at 19 Euro per tonne $CO_{2equiv.}$



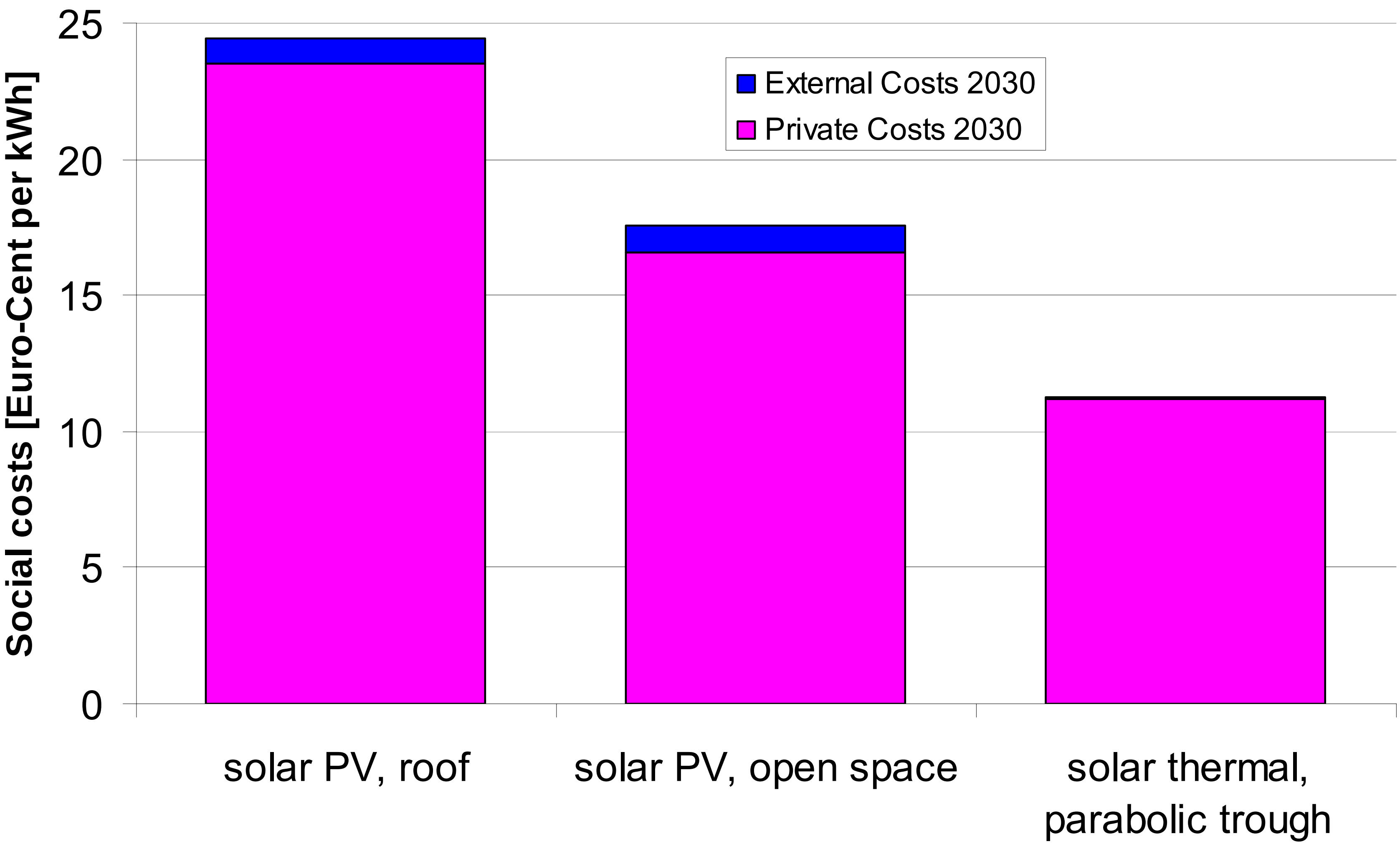
Context! Total Social Costs [Euro-Cent$_{2005}$ per kWh$_{el}$] in 2010



Total Social Costs [Euro-Cent$_{2005}$ per kWh] – Ranking in 2010



An estimation of Social Costs [Euro-Cent$_{2005}$ per kWh$_{el}$] in 2030



Summary - Conclusions

- ✓ IPA is necessary to estimate actual impacts of emissions because they can be very site specific
- ✓ Total social costs and not only environmental performance nor only private costs have to be taken into account
- ✓ External costs of solar electricity are low
- ✓ Social costs of solar electricity decreases in future. However, they will be still up to an order of magnitude higher than conventional technologies.

More information

ExternE:	http://www.ExternE.info
EcoSenseWeb:	http://EcoSenseWeb.ier.uni-stuttgart.de
NEEDS project:	http://www.needs-project.org
CASES project:	http://www.feem-project.net/cases

Acknowledgements

- NEEDS and CASES project

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